The Chemistry Gas Law Portfolio

1. Describe the practice proposed for recognition, and list its objectives. Detail how the practice is innovative and how it promotes high student achievement.

The gas law unit in a high school chemistry course includes many abstract ideas of the Kinetic Theory, including pressure, molecular motion and ideal vs. real behavior of gases. Ultimately these concepts must be quantitatively related. During the gas law unit, each student produces a portfolio which is utilized to assess their progress and learning. The portfolio is an alternative assessment to a traditional, quantitative unit test.

The students compile documents in the portfolio to evidence progress and improvement, or special challenge. The portfolio evaluates their knowledge of the gas law unit. This knowledge consists of qualitative and quantitative concepts. The students write a beginning goal statement and brainstorm with the teacher to create an evaluation rubric. Every document must be identified with a caption statement to explain the evidence and relate what purpose it serves in the portfolio. Students may include homework, class notes, prelab flowcharts, lab reports, quizzes, scientific drawings/sketches, magazine articles, etc. The students may include research on the gas law scientists from around the world. The included papers must demonstrate learning, for example, rewritten notes and corrections to quizzes and analysis questions from labs.

A major part of the portfolio is the creative section. Students may conduct experiments, create demonstrations, make posters, write poetry, stories or songs, build models, or creatively portray knowledge of the gas laws. This section encourages individuality and originality beyond the required chemistry and math curriculum. During the unit, students keep a journal in which they record interesting facts, questions and documentation of their progress. At the conclusion of the portfolio process, a reflective statement is written.

The portfolio is a dynamic project and is kept in the classroom because it is periodically revisited by the students to edit and/or replace improved evidence of learning. The portfolio is expected to change over time as students document additional learning.

At the completion of the unit, students make oral presentations of their portfolio and their creative section to their peers during class. A question and answer session with the teacher and classmates concludes the presentation. No written quantitative test is administered.

The major objectives of this project are to offer an alternative methodology for evaluation of a quantitative unit and to improve achievement for students with varying mathematical abilities. This portfolio is an alternative assessment, replacing the traditional unit test because student performance on that quantitative test varies with mathematical ability. The best science students are not always the students who receive the best grades due to mathematical and test-taking skills.

Improved science learning and teaching are other objectives. Educational research advocates the use of a portfolio to monitor student interest and attitude as well as augment growth in problem solving, processing skills and concept attainment. The final objective is the fostering of interconnections between science, mathematics and the humanities as well as to real-world situations.

While there are numerous references in the research regarding alternative assessment and portfolio use in particular, there is a scarcity of data on implementation of these methodologies in high school science, especially chemistry. The portfolio is innovative because it addresses this

limitation in the chemistry curriculum and adds an element of creativity for the students.

During the portfolio production, high student achievement is promoted. Students are actively engaged and utilize multiple intelligences during the entire unit. Students are in control of their learning process and exhibit high levels of motivation, excitement about the process and willingness to invest time and energy into the project. They take responsibility for their learning by prioritizing and structuring their own work. They frequently state connections to real-life issues involving the gas laws. The students are well aware that they have set goals and have accomplished them. The majority of students are academically successful with this alternative task. They successfully learn the gas laws, qualitatively and quantitatively. The portfolio is a reliable and effective measure of improving student achievement, especially for those students with weak mathematical skills.

2. List the specific *Core Curriculum Content Standards, including the Cross-Content Workplace Readiness Standards* addressed by the practice and describe how the practice addresses those standard(s). Provide an example to substantiate your response.

Science Standards:

#5.1-*Identify systems of interacting components and understand how their interactions combine to produce the overall behavior of the system.* Students learn about the interaction of volume, temperature, pressure and particles in gas law systems by conducting experimental laboratories, viewing demonstrations and learning how to solve complex gas law problems.

#5.2-*Develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.* Students reflect in their journals and the concluding reflective statement on questions, experiments, observations, analysis and conclusions from demonstrations, lab experiments and their creative section. They may research or design demonstrations or experiments. They utilize appropriate instrumentation in their laboratory investigations. They present the results of their learning to their peers.

#5.3-*Develop an understanding of how people of various cultures have contributed to the advancement of science and technology and how major discoveries and events have advanced science and technology.* Students study the many, world-wide scientists involved in the quest for knowledge about the gas laws. They may research a particular scientist's contribution to the Kinetic Theory.

#5.4-*Develop an understanding of technology as an application of scientific principles.* Students learn how the advancement of technologies (cathode ray tubes, gas chromatography, etc.) contributes to scientists' understandings of the ideal and real world of gases. They personally utilize calculator-based lab equipment to collect and analyze data with probes, graphing calculators and computers.

#5.5-*Integrate mathematics as a tool for problem-solving in science and as a means of expressing and/or modeling scientific theories.* Students predict and calculate the results of varied conditions on real and ideal gases. They quantitatively relate the interaction of volume, temperature, pressure and particles and demonstrate those relationships on computer spreadsheets and graphs. After experimentally collecting data, they utilize graphing calculators to graph and

analyze the data. They develop mathematical models to predict physical behaviors of gases, such as diffusion, implosion and explosion.

#5.8-*Gain an understanding of the structure and behavior of matter.* Students gain an understanding of the behaviors that result from the varied structure and bonding of gaseous molecules. Students study the inert noble gases and the reactions that occur with other gases.

#5.12-*Develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.* Students understand the effect and interplay of human activities and the accelerated greenhouse effect in Earth's atmosphere. By studying global warming and greenhouse gases, students realize the importance of conservation of resources and energy.

Cross-Content Workplace Readiness Standards

#1-*Career planning and workplace readiness skills.* Students demonstrate originality, technical skills and artistic expression in the production and presentation of their individual portfolios, especially the creative section. They apply mathematics in real-life situations involving gases. They recognize the role of the scientific community, for example, chemists involved in photography, pharmaceutics industries, aeronautics, climate and the atmosphere.

#2-*Technology, Information and other tools.* Students utilize varied methods to access and convey information including electronic data collection devices, graphing calculators and computers. They have access to various applications, such as Graphical Analysis and the Internet. They use technology to gather, analyze, display and present their findings.

#3-*Critical thinking, decision making and problem solving.* Students must revisit their portfolios during the unit in order to document improvement. They decide which documents will be included. Students identify and solve problems in experimental designs produced to explain gaseous behavior. They recognize multiple methods of solving gas law problems and compare the alternative solutions. They study divergent scientific findings.

#4-*Self-management skills.* In the production of the portfolio, the students manage the documentation of learning. They participate in a long-term project. They critique their work and reflect on their increasing knowledge. Students keep a journal of their progress, observations and questions. They communicate the results of their portfolio to their peers.

#5-*Apply safety principles.* Students utilize technological equipment to augment their studies and to conduct gas law experimental investigations, analysis and presentations. They utilize laboratory equipment appropriately and safely. They perform demonstrations with proper regard to safety and environmentally sound disposal of all chemicals.

Example: The Creative Section of the portfolio

This section of the portfolio provides the teacher and the students many opportunities to address the standards. In addition to the many chemistry standards covered (Science Standards #5.1-5, 8 and 12), the production of the portfolio encourages originality, technical skills and artistic expression. The students must relate some aspect of the gas laws in a creative, original way. Many students write stories, poems and songs, or conduct experiments and demonstrations. One student brought in his mountain bike pressure shocks and explained how gases compress to provide cushioning and improved abilities for the rider. Another student demonstrated the mechanics of her scuba tank, the mixture of gases and the pressure gauges. She connected the scuba tank technology to Dalton's Law of Partial Pressure with graphs and diagrams. Yet another student created a slide show on the workings of a hot air balloon with an interactive graph

demonstrating the changes in temperature and pressure. A three-dimensional wooden sculpture of a graphical interpretation of the Combined Gas Law was created by one student. This sculpture is used annually to explain this law and to exhibit the caliber of creativity demonstrated by students. (Cross-Content Workplace Readiness Standards #1 and #2)

Self-management skills are learned as students evaluate their creative ideas with their peers. Constructive criticism leads to better creative projects and improved documentation of learning. Decisions are made regarding the advantages of inclusion of varying documents in this section of the portfolio. Oral communication is improved as students prepare for the final presentation of their "creation". (Cross-Content Workplace Readiness Standards #3 and #4) As each student evaluates the creative section, he or she weighs evidence and recognizes alternative arguments and explanations. They prepare to defend their ideas. (Science Standard #5.2)

3. Describe the educational needs of students that the practice addresses. Document the assessment measures used to determine the extent to which the objectives of the practice have been met. Provide assessments and data to show how the practice met these needs.

The portfolio project was developed for high school students enrolled in a first-year chemistry course. These students needed an alternative assessment to successfully demonstrate chemical knowledge, not necessarily mathematical knowledge. A rubric was developed with student input and utilized to evaluate the portfolio. The rubric describes what may be included. Students are evaluated on organization and presentation of the portfolio. They are evaluated for content as well as creativity and originality throughout the portfolio. Students may include a Wild Card to demonstrate further knowledge. Progress and improvement must be demonstrated and documented. Science process skills must be exhibited. All included evidence must show relevance to real-life situations and experiences.

During the experimental year, students were also administered the quantitative test after completion of the portfolio project. Among other findings, a significant correlation was found (Spearman Rank Ordering) between the two means for the portfolio and the gas law test (N=60). This suggested that the alternative assessment was a reliable instrument for measuring achievement. The experimental group performed as well, statistically, as a control group. Additionally, there was an improvement in percentage points earned on the traditional gas law test (versus grades on a similar quantitative heat unit test) for lower-level mathematically-challenged students from the experimental group. This suggested that the mathematically-challenged students improved their achievement on the traditional test by creating the portfolio.

The four successive years following the experimental year have produced similar results for the first-year chemistry students. During the second-year chemistry course (AP Chemistry), students are successful with the gas law unit at that level. They demonstrate high interest, recall and understanding for abstract and concrete objectives. They perform well on advanced quantitative gas law problems.

4. Describe how you would replicate this practice in another school and/or district.

This portfolio project would be easily replicated in any high school chemistry course. The teacher would utilize his normal lesson plans from traditional units. The major change would be evaluation by portfolio instead of a traditional test. Also, the students would be more involved in the planning and more active in the acquisition of knowledge. Because it is not a year-long or marking period-long project, it could be used for any quantitative unit, in any science course, to bolster student interest and provide an alternative assessment.